

REMARKS

Claims 20 through 29 have been added. Claims 1 through 19 have been cancelled. Claim 20 is in independent form.

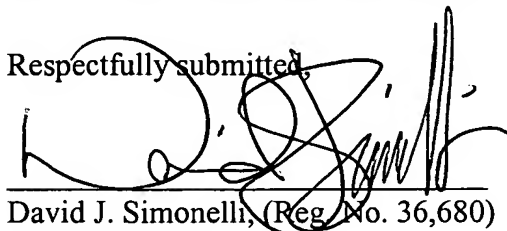
The specification has been amended to more accurately describe the invention of Applicant. No new matter has been added to the specification. The edits and amendments thereto are to correct grammatical issues with the translation of the original German patent application.

Claims 20 through 29 have been added. These claims do not add new matter. These claims have been submitted replacing the cancelled claims 1 through 19 to clarify the invention by placing the claims in a form suitable for prosecution before the United States Patent and Trademark Office.

It is respectfully submitted that this patent application is in condition for allowance, which allowance is respectfully solicited. If the Examiner has any questions regarding this amendment or patent application, the Examiner is invited to contact the undersigned.

The Commissioner is hereby authorized to charge any additional fee associated with this Communication to Deposit Account No. 50-1759. A duplicate of this form is attached.

Respectfully submitted,



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**Process for the Production of Light-Emitting Semiconductor Diodes on a Printed Circuit Board and Lighting Units with Integrated Printed Circuit Boards**

**DESCRIPTION: METHOD FOR THE PRODUCTION OF LIGHT-EMITTING SEMICONDUCTOR DIODES**

**Background Art**

**1. Field of the Invention**

[0001] The invention relates to a process for the production of at least one light-emitting semiconductor diode on a printed circuit board ~~comprising printed conductors, as well as a lighting unit which comprises.~~ More particularly, the invention relates to production of a light-emitting semiconductor diode on a printed circuit board which comprises electrical printed conductors and is assembled with at least one light-emitting chip and at least one light distributing body encircling a light-emitting chip or a group of light-emitting chips in such a manner that it contacts them with an optical element affixed thereto.

**2. Description of the Related Art**

[0002] A light-emitting semiconductor diode, e.g. a light-emitting diode or a laser diode, customarily ~~comprises~~ includes an electrical part and a light distributing body which encircles ~~said~~ the electrical part at least in certain areas and is at least substantially transparent. Luminescent diodes of this type are used, ~~for example,~~ in lights for automobiles, for room lighting, in light modules for communication, in street lights, and ~~so on~~ the like.

[0003] A lighting unit can ~~comprise~~ include several light-emitting semiconductor diodes ("light-emitting diodes") produced on one printed circuit board. The component designated here as printed circuit board can be resistant to bending or susceptible to bending. It can also have the form of foil, where the foil can be resistant to bending or susceptible to bending.

[0004] A process for the production of light-emitting diodes is known from JP 61 001 067 A. For the formation of the light distribution body in the resin-molding process, the light-

emitting chip placed on the printed circuit board is molded around with a resin which penetrates the narrow through holes in the printed circuit board. On drying of the resin, there is a strong shrinkage of the material, whereby the geometry of the light distribution body changes. With this process therefore, only geometrically simple light-emitting diodes can be produced. In addition, the tensile strength of the resin is low. During production as well as during operation, e.g., with a high-power light-emitting chip, mechanical stresses can thus appear. For example, the light distribution body breaks apart. ~~The~~ And the light unit fails.

[0005] The problem underlying the present invention is to develop a process for reproducible production of a high-power light-emitting semiconductor diode on a printed circuit board as well as a corresponding lighting unit with integrated printed circuit board.

[0006] ~~This formulation of the problem is solved with the features of the independent claims. In production, at least one light-emitting semiconductor chip is placed on the printed circuit board. Thereafter, the light-emitting semiconductor chip is electrically and mechanically connected to the printed circuit board in a thermally conducting manner. The thus pre-assembled printed circuit board is introduced into an injection mold. Subsequently, the injection mold is injected with a thermoplast which penetrates the printed circuit board through at least one through hole or flows around the printed circuit board.~~

[0007] ~~The light distribution body thus produced consists of a thermoplast. It projects through at least one through hole of the printed circuit board with at least one feedthrough link and lies on the assembly side as well as on the printed circuit board's other side opposite the assembly side. The minimum cross-sectional surface of an individual feedthrough link is at least 10% of the application surface of the light distribution body on the assembly side and on the light-emitting chip. The minimum dimension of the cross-sectional surface is at least a fifth of the maximum dimension of the cross-sectional surface and the application surface of the light distribution body on the other side of the printed circuit board is at least 75% of the cross-sectional surface.~~

### Summary of the Invention

[0008] A method is disclosed for creating a light assembly including a light-emitting diode and a printed circuit board having conductors printed thereon. The method includes the steps of positioning the light-emitting diode on the printed circuit board. Once positioned, the light-emitting diode is connected to the printed circuit board. The light-emitted diode and the printed circuit board are positioned in a mold. A thermoplast is injected into the mold such that

the thermoplast extends on both sides of the printed circuit board and over the light-emitting diode.

### **Brief Description of the Drawings**

[0009] ~~Further details of the invention follow from the subordinate claims and the following description of schematically represented forms of embodiment.~~ Advantages of the invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1: ~~light emitting diode, mounted on a printed circuit board,~~

[0010] Figure 1 is a partial cross-sectional side view of one embodiment of the invention;

[0011] ~~Figure 2: light emitting diode, as in figure 1 with~~ is a partial cross-sectional side view of a second embodiment of the invention having a chip carrier, secured thereto;

[0012] ~~Figure 3: light emitting diode~~ is a side view of the invention with integrated an optical lens;

[0013] ~~Figure 4: light emitting diode with bond wire,~~ is a side view of the invention with a premounted chip carrier;

[0014] ~~Figure 5: light emitting diode as in figure 2 with bond wire,~~

[0015] Figure 5 is a partial cross-sectional side view of the embodiment of Figure 4;

[0016] Figure 6: light-emitting diode with two bond wires,

[0017] ~~Figure 7: light emitting diode according to figure 2 in dimetric view,~~ is a perspective view of the invention;

[0018] ~~Figure 8: light emitting diode with~~ is a partial cross-sectional side view of one embodiment of the invention with a light guide, secured thereto;

[0019] ~~Figure 9: is a cross-sectional longitudinal section of a lighting unit,~~ view of the invention;

[0020] Figure 10: is a partial cross section of a lighting unit the invention according to figure 9, Figure 9;

[0021] Figure 11: is a partial plan view of a lighting unit the invention according to figure 9, Figure 9;

[0022] Figure 12: is a cross-sectional longitudinal section view of a lighting unit the invention with a grid-like printed circuit board;

[0023] Figure 13: is a partial cross section of a lighting unit the invention according to figure 12, Figure 12; and

[0024] Figure 14: is a partial plan view of a lighting unit the invention according to figure Figure 12.

#### **Detailed Description of the Preferred Embodiment(s)**

[0025] Figure 1 shows an individual light-emitting diode (20) which is produced on a printed circuit board (40).10. This light-emitting diode (20) is, ~~for example, a single~~ one of a plurality of light-emitting diodes (20) which are mounted on a common printed circuit board (10) in such a manner that they cannot be removed.

[0026] The printed circuit board (10) is, ~~for example, a bending~~ bend-resistant panel, made of plastic or a composite built up of electrically non-conducting materials, on whose upper side (41).11, or underside, electrical printed conductors (12, 13) are applied. The printed conductors (12, 13) are coated at least in certain areas with a passivation layer (44).14. The printed circuit board (10) can, ~~for example,~~ also be a metal printed circuit board on whose insulated surface, ~~for example,~~ printed conductors can be laminated.

[0027] In the printed circuit board (40), ~~for example, 10~~, three through holes (15, 16) are disposed. Two through holes (15) lie in the area of the printed conductors (12, 13) while one through hole (16) lies outside of the printed conductors (12, 13).13. The distance of the two through holes (15) from one another corresponds, ~~for example,~~ to the distance of the through hole (45).15, represented here on the left, from the through hole (46).16. The through holes (45).15, cf.

~~figure~~Figure 7, are, ~~for example,~~ long holes which penetrate the printed conductors (12, 13) and the printed circuit board (10). ~~Here, for example, they~~10. They are disposed so as to be parallel to one another.~~Here, for example, the~~ The through hole (16) is also a long hole which lies parallel to the long holes (15) and is approximately half as long as they are. The bounding edge of the long hole (16) lying on the upper side (11) is an alignment edge ~~(18)~~18.

[0028] For the production of the light-emitting diode ~~(20)~~20, a light-emitting semiconductor chip (21) is placed on the thus prepared printed circuit board ~~(10)~~10. During the placement its position is aligned to the alignment edge ~~(18)~~18. The light-emitting semiconductor chip (21) is fastened to the printed conductors (12, 13) with ~~a, for example, electrical~~electrically and thermally conducting adhesive and/or solder connection (22) at the points which are free of the passivation layer ~~(14)~~14. Instead of a single light-emitting semiconductor chip ~~(21)~~21, a group of light-emitting semiconductor chips (21) can also, ~~for example,~~ be placed on the printed circuit board (10) and connected with the printed conductors (12,13) in such a manner that the connection is electrically and thermally conducting. The component designated here as light-emitting semiconductor chip (21) can also ~~comprise~~include a group of individual light-emitting semiconductor chips. In addition, other electrical components, such as, ~~for example,~~ resistors, capacitors, etc. can be integrated. It can ~~comprise~~include a plurality of electrical connections. The ~~thus-assembled~~ printed circuit board (10) can now, through connection of the printed conductors (12, 13) to a direct current source, be tested electrically.

[0029] In the next step of the process the light distribution body (31) is produced. For this, the assembled printed circuit board (10) is introduced, ~~for example,~~ into an injection mold which is not represented. Here, the upper side (11) of the printed circuit board (10) with the light-emitting semiconductor chip (21) points downward. On introduction into the injection mold, the printed circuit board (10) is laid on and aligned, with the alignment edge ~~(18)~~18, to a counter contour of the injection mold.

[0030] After closing the injection mold, a thermoplast, e.g. PMMA, is injected into the cavity of the injection mold. The air in the mold will be expelled and/or suctioned off. The cavities of the mold are filled with thermoplast. In given cases, the interstice (23) between the light-emitting semiconductor chip (21) and the printed circuit board (10) is first filled with

another material. The thermoplast penetrates through the through holes (15) of the printed circuit board (10) and engages behind the printed circuit board ~~(10)~~10. The injection mold is shaped in the form of the light distribution body (31) on the printed circuit board ~~(10)~~10. The light distribution body (31) thus produced has, ~~for example~~, the form of a half ellipsoid. It is homogeneous and highly transparent. By the engagement behind, the light-emitting diode (20) is connected, in a fixed manner, to the printed circuit board (10) and can be removed from it only with destruction.

[0031] After the production of the light distribution body ~~(31)~~31, the electrical printed conductor (12, 13) project, e.g. in the radial direction, over the light distribution body ~~(31)~~31. The light-emitting diode (20) thus produced can now be withdrawn from the injection mold. On drying and cooling, the form of the light distribution body (31) essentially does not change at all.

[0032] It is subsequently possible to injection-mold around the light-emitting diodes (20) on the printed circuit board (10) once again in an additional processing step. The processing steps can be spatially and/or temporally separated. Here, ~~for example~~, an optical lens can be formed on the light-emitting diode ~~(20)~~20. In a sequence of processing steps of this type, a standard module can, ~~for example~~, be produced in the first injection molding step, which then obtains its final form in the second injection molding step.

[0033] With this process, a light-emitting ~~semiconductor~~-diode 20 with high power can be reproducibly produced on a printed circuit board. In so doing, a homogeneous light distribution body arises, whose form does not change after its withdrawal from the injection mold. Furthermore, a plurality of forms of the light-emitting semiconductor diode can be realized with this process. The light distribution body 31 can have backcuts, only capable of being produced by injection-molding process, and can ~~comprise~~include an optical lens, a surface of free form, a diffraction surface, or a fractional surface.

[0034] Figure 2 shows a light-emitting diode (20) with a chip carrier ~~(24)~~24. The chip carrier (24) can be, ~~for example~~, a heat insulator, a reflector, a heat sink, and ~~so on~~the like. It can, ~~for example~~, also be built up in multiple layers. Thus, the chip carrier (24) can ~~comprise~~include a

thermal insulation layer on which a reflective layer is applied. The chip carrier (24) can also have electrically conducting areas.

[0035] In the production of the light-emitting diode (20) on the printed circuit board (10) the light-emitting semiconductor chip (21) is, ~~for example,~~ first placed on the chip carrier (24) and, ~~for example,~~ connected with an electrical and thermally conducting adhesive and/or solder connection (22) to an electrically conducting area of the chip carrier (24).24.

[0036] The light-emitting semiconductor chip (21) is then mounted together with the chip carrier (24) on the printed circuit board (10) and aligned to the alignment edge (18). ~~Here, for example, an~~18. An electrically and thermally conductive adhesive and solder connection (26) between the chip carrier (24) and the printed circuit board (10) is produced ~~and thus to electrically connect~~ the light-emitting semiconductor chip (21) ~~is electrically connected~~21 to the printed circuit board (10).10.

[0037] The assembled printed circuit board (10) is then, as described in the first embodiment example, introduced into an injection mold, aligned by means of the alignment edge (18),18, and injected around.

[0038] Figure 3 shows a light-emitting diode (20) with an integrated optical lens (32).32. Here, the printed circuit board (10) has, ~~for example,~~ two alignment edges (18, 19).19. The alignment edges (18, 19) are, ~~for example,~~ two outer edges of the printed circuit board (10) which are disposed so as to be perpendicular to one another.

[0039] In the mounting of the light-emitting semiconductor chip (21) on the printed circuit board (10),10, the position of the light-emitting semiconductor chip (21) is aligned to the printed circuit board (10) ~~by means of~~10 using the alignment edges (18, 19).19.

[0040] If the printed circuit board (10) assembled with the light-emitting semiconductor chip (21) is introduced into the injection mold, it is aligned, e.g. with the alignment edges (18, 19),19, to the counter contour ~~in~~of the injection mold.



[0041] On introduction of the thermoplast into the injection mold, the thermoplast flows around the printed circuit board (10) and penetrates the through holes (15).15. The light distribution body (31) produced in the injection molding, here represented above the printed circuit board (10).10, can, ~~for example, be formed to~~ have the structure of an ellipsoidal frustum whose upper side ~~comprises~~includes an optical lens (32).32. The diameter of this ellipsoidal frustum grows, ~~for example,~~ constantly from the printed circuit board (10) out in the direction of the optical lens (32).32. The maximum diameter of the ellipsoidal frustum corresponds to the diameter of the optical lens (32) and is approximately twice its height. Its minimum diameter near the printed circuit board (10) is, ~~for example,~~ approximately 80% of this diameter.

[0042] Here the optical lens (32) is a plane lens which is integrated into the light distribution body (31).31. However, the optical lens (32) can also have the structure of a convergent lens, a divergent lens, a prism face, a face of free form, a fractional face, a diffraction face, and ~~so on~~the like.

[0043] The light-emitting diodes (20) represented in ~~figures~~Figures 4 and 5 are produced in a manner similar to that of the light-emitting diodes (20) which are shown in ~~figures~~Figures 1 and 2.The In some instances, the light-emitting semiconductor chip (21) is ~~in given cases~~ premounted on a chip carrier (24).24, set on the printed circuit board (10).10, and aligned to the alignment edge (18).18.

[0044] In these embodiment examples, the light-emitting semiconductor chip (21) is fastened only to one printed conductor (12) with an adhesive and solder connection (22).22. The other electrical printed conductor (13) is connected electrically via a bond wire (27) to the light-emitting semiconductor chip (21).21. In ~~figure~~Figure 6 a light-emitting diode (20) is represented in which the light-emitting semiconductor chip (21) is connected to the printed conductors (12, 13) by means of two bond wires (27).27.

[0045] The light-emitting semiconductor chip (21) is introduced into a hollow (41) of the printed circuit board (10) which, ~~for example,~~ is coated with a reflecting layer (42).42. On introduction of the light-emitting semiconductor chip (21) its position is aligned, ~~e.g. at~~ using the two alignment edges (18, 19).19.

[0046] Figure 8 shows a light-emitting diode (20) with a light guide ~~(51)~~51. The light guide (51) can be rigid or flexible. It is, ~~for example,~~ fastened in the light distribution body (31) with a clip connection ~~(52)~~52, formed onto it, and ~~so on~~the like. Also, other form-locking and/or force-locking connections are conceivable.

[0047] In the production of this light-emitting diode ~~(20)~~20, the material of the light distribution body (31) penetrates the, ~~for example,~~ two ~~large~~-through holes ~~(15)~~15. The light distribution body (31) engages behind the printed circuit board (10) and lies with its full surface on the printed circuit board ~~(10)~~10, on one side of the printed circuit board ~~(10)~~10, specifically the side facing away from the light-emitting semiconductor chip ~~(21)~~21.

[0048] The alignment edge (18) can be an edge of an alignment face. This alignment face can, ~~for example,~~ be the inner wall of a wedge-like or cylindrical hole, the wall of a cylinder, the outer surface of the printed circuit board ~~(10)~~10, the wall of a cylindrical pin, and ~~so on~~the like.

[0049] On introduction of the printed circuit board (10) assembled with the light-emitting semiconductor chip (21) into the injection mold, the light-emitting semiconductor chip ~~(21)~~can also be is aligned with respect to the injection mold. Here, the light-emitting semiconductor chip (21) can be disposed, ~~for example,~~ so as to be normal to the optical axis of the light distribution body (31) to be produced, in or near the origin of the contour of the light distribution body ~~(31)~~31, and ~~so on~~Here the like. The origin is a prominent point in relation to a physical property or a geometrical boundary condition for the description of the contour of the light distribution body ~~(31)~~31.

[0050] On introduction of the printed circuit board (10) assembled with the light-emitting semiconductor chip (21) into the injection mold, the light-emitting semiconductor chip (21) can lie below, above, or to the side of the printed circuit board ~~(10)~~10. In the injection molding, the thermoplast can be fed from the side of the light distribution body ~~(31)~~31, from the underside of the printed circuit board ~~(10)~~10, or from the side.

[0051] The thermoplast can flow around a printed circuit board ~~(10)~~10, which, ~~for example,~~ ~~comprises~~ includes no through holes ~~(15)~~15. The finished light distribution body (31) then engages around the printed circuit board ~~(10)~~10.

[0052] The printed circuit board (10) can be built up in multiple layers. ~~Thus they~~ They can, ~~for example,~~ have several printed conductors (12, ~~13~~)13. In addition, they can ~~comprise~~include a metal core for discharging heat of the light-emitting semiconductor chip (21), ~~comprise~~21, include a coating, and ~~so on~~the like.

[0053] The printed circuit board (10) can be a foil, onto which printed conductors (12, 13) are applied. An alignment edge (18) is then, for example a limiting edge of the foil, a punched-through hole, and ~~so on~~the like.

[0054] The light-emitting chip (21) or a group of light-emitting chips (21) can have three or more electrical connections in all the forms of embodiment represented. They can be electrically and/or thermally conductive adhesive connections (~~22~~),22, bond wires (~~27~~),27, and ~~so on~~the like. Also, combinations of electrical connections of different types are conceivable. The light-emitting diode (20) can, ~~for example,~~ then, depending on the electrical connection, illuminate at different levels of brightness or in different colors.

[0055] The thermoplast has a low optical damping. The light-emitting diodes (20) produced with the process and produced on a printed circuit board (10) have small size and high light output.

[0056] In the production of several light-emitting diodes (20) on one printed circuit board (~~10~~),~~they~~10, the thermoplast can be introduced in one common injection mold. The injection mold can then ~~comprise~~include a single sprue for each individual light distribution body (~~31~~)31. However, several, or all, of the light distribution bodies (31) can be produced by injection molding via a common sprue.

[0057] Figures 9 to 11 show a lighting unit (110) with an integrated printed circuit board (~~120~~)120. On the printed circuit board (120) sit, ~~for example,~~ two light-emitting chips (~~140~~)140. Each of these light-emitting chips (140) is, ~~for example,~~ encircled by a light distribution body (150) fastened to the printed circuit board (~~120~~)120. A light distribution body (150) can also, ~~for example,~~ encircle several light-emitting chips (~~140~~)140, e.g. a group of light-emitting chips (~~140~~)140.

[0058] The component designated here as printed circuit board (120) can, ~~for example,~~ be a foil which is subject to bending or resistant to bending, a plate made of fiber-reinforced plastic or built up from electrically non-conductive composite material, a metal printed circuit board with insulated surface, a ceramic printed circuit board, and ~~so on~~ the like. On its assembly side (121) on which the light-emitting chip (140) is disposed and/or on its unassembled side (~~122~~), 122, electrical printed conductors, not represented here, are applied or laminated.

[0059] The printed circuit board (120) ~~comprises, for example,~~ 120 includes four through holes (~~123~~), 123. These through holes (123) are, ~~for example,~~ long holes (125, 126) which are curved in the form of a parabola and whose width is approximately one fourth of their length. The width of the long holes (125, 126) is, ~~for example,~~ greater than the length of the diagonals of one of the light-emitting chips (140) represented here as square. Each two of these long holes (125, 126) are disposed so as to be symmetric to one another, where the respective plane of symmetry contains the midpoint (141) of the surface (142) of a light-emitting chip (~~140~~), 140. The printed circuit board (120) can, ~~for example,~~ also ~~comprise~~ include three through holes (~~123~~), 123, of which, ~~for example,~~ two lie so as to be symmetric to the light-emitting chip (140) and the third lies at an arbitrary point in the vicinity of the chip (~~140~~), 140. The through holes (123) can also have a rectangular, circular, etc. cross section.

[0060] The single light-emitting chip (140) is, ~~for example,~~ a semiconductor chip of an inorganic or organic type and can develop a high light intensity. It is connected to the electrical printed conductors of the printed circuit board (120) in such a manner that is electrically conductive. Furthermore, there is a thermally conductive connection between the light-emitting chip (140) and the printed circuit board (~~120~~), 120. It can be rectangular, round, hexagonal, etc. in plan view.

[0061] The single light distribution body (150) is a, ~~e.g.~~ completely transparent, body which consists of a, ~~for example,~~ homogenous thermoplast, e.g. PMMA, polycarbonate, polysulfone, and ~~so on~~ the like. It ~~comprises, for example,~~ includes a light distribution section (161) lying on the assembled side (121) of the printed circuit board (120) and a fastening section (163) lying on the unassembled underside (~~122~~), 122. The contours of the application faces of the light

distribution body (150) on the two sides (121, 122) of the printed circuit board are congruent to one another and lie against one another.

[0062] The light distribution section (161) ~~comprises~~ includes a cylinder ~~(164), 164,~~ a light deflection body ~~(165), 165,~~ and an optical lens ~~(166), 166.~~ Its height normal to the printed circuit board (120) is at least the thickness of the printed circuit board. In the embodiment example the height is approximately five times the thickness of the printed circuit board.

[0063] The cylinder (164) stands, ~~for example,~~ perpendicular to the printed circuit board ~~(120), 120.~~ Its generating curve, which lies in a plane parallel to the printed circuit board ~~(120), 120,~~ is composed of a parabolic section and a straight line. The length of the cylinder (164) corresponds to the height of the light-emitting chip ~~(140), 140.~~ The light-emitting chip (140) lies with its midpoint (141) on the normal at the focal point of the parabolic section.

[0064] The light deflection body (165) has, ~~for example,~~ the structure of a half-paraboloid, e.g. a paraboloid of rotation or an elliptical paraboloid. It stands on the cylinder ~~(164), 164,~~ where the respective surfaces make a transition into one another. The midpoint (141) of the surface (142) of the light-emitting chip (140) lies, ~~for example,~~ at the focal point of the half-paraboloid. The light deflection body (165) ~~comprises~~ includes an optical lens (166) standing approximately perpendicular to the printed circuit board ~~(120), 120.~~ This optical lens (166) can, ~~for example,~~ be a convergent lens, a divergent lens, and ~~so on the like.~~ The light distribution section (161) can be embodied without a light deflection body ~~(165), 165.~~ It can, ~~for example, comprise~~ include a simple optical lens.

[0065] The fastening section (163) ~~comprises~~ includes a plate-like wraparound ~~(156), 156.~~ This has, ~~for example,~~ a constant material thickness, which, ~~for example,~~ corresponds to the thickness of the printed circuit board ~~(120), 120.~~ In given cases, tabs can also be disposed on the fastening section ~~(163), 163,~~ said tabs projecting, ~~for example,~~ in the direction normal to the underside (122) of the printed circuit board.

[0066] The light distribution section (161) and the fastening section (163) are, ~~for example,~~ connected to one another by means of two feedthrough links (152, ~~154), 154,~~ each of which projects through a long hole (125, 126) of the printed circuit board ~~(120), 120.~~ The feedthrough

links (152, 154) are, ~~for example,~~ disposed so as to be symmetric to one another, where the plane of symmetry contains the midpoint (141) of the light-emitting chip ~~(140)~~140.

[0067] If the printed circuit board (120) ~~comprises~~ includes several through holes (123) in the vicinity of the light-emitting chip ~~(140)~~140, the light distribution section (161) and the fastening section (163) can also be connected to one another via several feedthrough links (152, 154)154.

[0068] These feedthrough links (152, 154) have, e.g. along their height normal to the printed circuit board (120) – this corresponds to the thickness of the printed circuit board (120) - a constant cross-sectional surface (153, 155) which corresponds to the cross-sectional surface of the long holes (125, ~~126~~)126. This cross-sectional surface (153, 155) of a feedthrough link (152, 154) is in the representation of ~~figures~~Figures 9 – 11 approximately 28% of the application face with which the light distribution body (150) lies on the assembly (121) of the printed circuit board (120) and on the surface (142) of the light-emitting chip ~~(140)~~140. For example, the feedthrough links (152, 154) ~~comprise~~ include at the transitions to the light distribution section (161) and to the fastening section (163) load-relieving hollows.

[0069] The cross-sectional surface (153, 155) can, ~~for example,~~ vary between 10% and 60% of the above-mentioned application face.

[0070] The outer surfaces (167, 168, 169) of the light distribution section ~~(161)~~161, of the fastening section ~~(163)~~163, and of the feedthrough link (152, 154) have transitions into one another.

[0071] Here, the wraparound (156) connects both feedthrough links (152, 154) to one another. The application face of the wraparound (156) on the unassembled side (122) corresponds in the embodiment example represented here approximately to three times the cross-sectional surface (153, 155) of a feedthrough link (152, ~~154~~)154.

[0072] The production of the lighting unit (110) is done, ~~for example,~~ as described in connection with ~~figures~~Figures 1 – 7. First, the, ~~for example,~~ punched printed circuit board (120) is

assembled with the light-emitting chips (140) and the two parts (120, 140) are connected to one another in such a manner that the connection is electrically and thermally conductive.

[0073] The assembled the printed circuit board (120) is now, ~~for example,~~ introduced into an injection mold not represented here. The injection openings of the injection mold are located, ~~for example,~~ on the unassembled side (122) of the printed circuit board (120) and are, ~~for example,~~ aligned in the direction normal to the underside (~~122~~).122. The center of the injection jet then lies, ~~for example,~~ in the area below the chip, ~~for example,~~ below the geometric center of the through holes (123) within the injection mold.

[0074] During injection molding, the injection-molding material flows in the direction perpendicular to the underside (122) of the printed circuit board (~~120~~).120. The injection jet then flows, ~~for example,~~ onto the geometric center of the through holes (~~123~~),~~for example~~123, i.e., the center of mass of the through holes (~~123~~).123. There, it strikes the printed circuit board (~~120~~).120, which forms a flow divider for the flow of injection-molding material flowing onto it. The injection-molding material is distributed, ~~for example,~~ uniformly on both through holes (123) and builds up the light distribution body (150) on both sides of the printed circuit board (~~120~~).120.

[0075] During injection of the thermoplast, the air in the injection mold is expelled and/or suctioned off. The injection mold reproduces the form of the light distribution body (150) on the printed circuit board (~~120~~).120.

[0076] In given cases, the injection-molding material can be conducted by means of flow-conducting elevations or indentations on the injection mold and/or printed circuit board (~~120~~).120.

[0077] Through the engagement behind, the light distribution body (150) is connected in a fixed manner to the printed circuit board (120) and can be removed from it only with destruction.

[0078] The lighting unit (110) thus produced can now be withdrawn from the injection mold. In given cases, the production can also be done in two or more spatially and/or temporally separated manufacturing steps.

[0079] On drying and cooling of the light distribution body (150) tensile forces are exerted on the feedthrough links (152, ~~154~~).154. These forces are, ~~for example~~, directed in the direction normal to the assembly side (121) of the printed circuit board (~~120~~).120. The feedthrough links (152, 154) are extended. The extension is however, among other things, due to the large cross-sectional surface (153, 155) significantly less than the strain at break, which, ~~for example~~, for PMMA is 5.5%. The large application face of the wraparound (156) prevents in addition the development of cracks. With further cooling the tensile stresses arising in the material are, ~~for example~~, not relieved and lead, ~~for example~~, to intrinsic stresses in the material. The comparative stress of these intrinsic stresses is significantly less than the elastic limit of the material up to which the material is extended without permanent plastic deformation.

[0080] During the operation of the lighting unit (110), ~~for example~~, each light-emitting chip (140) can be individually electrically controlled. However, all the light-emitting chips (140) can be operated jointly. Also, control of the light-emitting chips (140) in groups is conceivable.

[0081] The light radiated from the light-emitting chip (140) is, ~~for example~~, deflected by total reflection in the light distribution body (150) in the direction of the optical lens (166) and radiated through it into the environment (~~1~~).1.

[0082] During the operation of the light-emitting chip (s) (~~140~~).140, a great amount of heat arises. A part of this heat is, ~~for example~~, discharged via the thermally conducting connection to the printed circuit board (~~120~~).120. Another part of the heat leads to a heating of the light distribution body (150) and the printed circuit board. The light distribution body (150) and the printed circuit board (120) expand, depending on their coefficients of thermal expansion and differences in temperature.

[0083] In the lighting unit (~~110~~).110, the printed circuit board (120) is firmly clamped in the light distribution body (~~150~~).150. If the printed circuit board (120) expands on heating, the light distribution body (150) prevents a deformation of the printed circuit board (~~120~~).120.

[0084] On heating of the printed circuit board (120) and/or the light distribution body (~~150~~).150, additional stresses, e.g. as variation in stress, act on the feedthrough links (152, ~~154~~).154. These are then, ~~for example~~, additional tensile stresses which act at least approximately in



the same direction as the intrinsic stresses applied due to the production process. The comparison stress of the superposition of these stresses is, due to the large cross section of the individual feedthrough links (152, ~~154~~), 154, lower than the elastic limit of the materials. At the same time, the section modulus of the respective cross-sectional faces (153, ~~155~~), 155, which is determined by the ratio of the dimensions of the cross-sectional faces (153, ~~155~~), 155, prevents a break or a permanent deformation of the feedthrough links (152, 154) due to bending or shearing. Thus, even with an oblique application of force on the feedthrough links (152, ~~154~~), 154, e.g. caused by the heating during the operation of the lighting unit (~~140~~), 110, no permanent deformation occurs. Likewise, removal of the light distribution body (150) and/or the light-emitting chip (140) from the printed circuit board (120) is prevented by the back-engagement of the light distribution body (150) around the printed circuit board (~~120~~), 120. The chip (140) of the light distribution body (150) and the printed circuit board (120) are affixed to one another mechanically so that the alignment of the light-emitting chip (140) to the light distribution body (~~150~~), and 150. And thus, the optical properties of the lighting unit, are retained long-term.

[0085] The light distribution body (150) can have another form on the assembly side (~~121~~), 121. Thus, ~~for example~~, the optical lens (166) can lie parallel to the assembly side (121) or in a plane inclined to the printed circuit board (~~120~~), 120. The light distribution body (150) can also have a similar, or the same, form on the two sides (121, 122) of the printed circuit board (~~120~~), 120.

[0086] Between the light distribution section (161) and the fastening section (~~163~~) 163, one or more feedthrough links (152, 154) ~~can be~~ are disposed. Each of these feedthrough links (152, 154) ~~can, for example~~, have a round, rectangular, triangular, trapezoidal, etc. cross-sectional surface (153, ~~155~~), 155. The individual cross-sectional surface (153, 155) is then at least 10% of the total of the application face of the light distribution body (150) on the assembly side (121) and the application face of the light distribution body (150) on the light-emitting chip (~~140~~), 140.

[0087] The fastening section (163) can, ~~for example, comprise~~ include several individual wraparounds (~~156~~), 156. The application face of each of these wraparounds (156) is then, ~~for example~~, 75% of the cross-sectional surface (153, 155) of the respective feedthrough link (152, ~~154~~), 154.

[0088] In ~~figures~~Figures 12 – ~~14~~14, a lighting unit with a grid-like printed circuit board (120) is represented. The light distribution body (150) corresponds in its external dimensions to the light distribution body (150) represented in ~~figures~~Figures 9 – 11.

[0089] The printed circuit board (~~120~~), ~~here~~here, 120, by way of example, is rectangular, ~~comprises and includes~~ a frame (124) whose longitudinal sides are connected to one another by printed circuit board links (~~131~~), 131. On each of the printed circuit board links (131) a light-emitting chip (140) sits. The frame (124) and the printed circuit board links (131) border the through holes (~~123~~), 123.

[0090] The cross section of the printed circuit board links (~~131~~), 131, cf. Figure 13, is, ~~for example~~, oval, where the maximum width of the individual printed circuit board links (131) lies in the central longitudinal plane of the printed circuit board (120) parallel to the assembly side (~~121~~), 121. The individual printed circuit board link (131) has in this embodiment ~~example~~ approximately half again the width of the light-emitting chip (~~140~~), 140. The cross section of the printed circuit board link (131) can also be rectangular, triangular, and ~~so on~~on the like.

[0091] The through holes (~~123~~) ~~comprise, for example~~, 123 include three approximately rectangular punched holes (128, 129) with rounded corners. The cross-sectional surface of the small punched holes (128) is approximately twice the surface of the printed circuit board links (131) on the assembly side (~~121~~), 121. The cross-sectional surface of the large punched holes (129) is approximately four times this surface.

[0092] The individual feedthrough link (152, 154) lies on the arched flank (132) of the printed circuit board link (~~131~~), 131. Its cross-sectional surface is not constant over the length of the feedthrough link (152, ~~154~~), 154. It has at the transition to the light distribution section (161) and to the fastening section (163) a maximum and in the center a minimum. The minimal cross-sectional surface (153, 155) of the feedthrough link (152, 154) in a plane parallel to the assembly side (121) here is approximately 120% of the application surface of the light distribution body (150) on the assembly side (121) of the printed circuit board link (131) and on the light-emitting chip (~~140~~), 140.

[0093] The two feedthrough links (152, 154) are disposed so as to be symmetric to one another. The plane of symmetry intersects the light-emitting chip ~~(140)~~140. The at least approximately triangular cross-sectional surfaces (153, 155) of the two feedthrough links (152, 154) are equally large. Their shortest dimension is, in this embodiment example, approximately 68% of the maximum dimension.

[0094] The application face of the light distribution body (150) on the unassembled side (122) of the printed circuit board (120) is in this embodiment ~~example~~ approximately 80% of the cross-sectional surface (153, 155) of the individual feedthrough links (152, ~~154~~)154. This installation surface lies opposite the application surface of the light distribution body (150) on the assembly side ~~(121)~~121. These external contours of the two installation surfaces are, at least approximately, equally large.

[0095] The application face (122) of the light distribution body (150) on the unassembled side of the printed circuit board (120) can, ~~for example~~, be up to approximately 120% of the cross-sectional surface (153, 155) of the individual feedthrough links (152, ~~154~~)154.

[0096] The production and the operation of this lighting unit (110) takes place as described in connection with the ~~figures~~Figures 9 – 11. Also, in this lighting unit (110) the light distribution bodies (150) are connected to the printed circuit board (120) in such a manner that they are mechanically affixed to one another. A removal of the light distribution body (150) and/or of the light-emitting chip (140) from the printed circuit board (120) is prevented by the feedthrough links (152, 154) as a matter of construction.

## List of reference numbers:

- 1 ——— Environment
- 10 ——— Printed circuit board
- 11 ——— Upper side of (10)
- 12 ——— Electrical printed conductor
- 13 ——— Electrical printed conductor
- 14 ——— Passivation layer
- 15 ——— Through holes, long holes
- 16 ——— Through hole, long hole
- 18 ——— Alignment edge
- 19 ——— Alignment edge
- 20 ——— Light-emitting diode
- 21 ——— Light-emitting semiconductor chip
- 22 ——— Adhesive and solder connection
- 23 ——— Interstice
- 24 ——— Chip carrier
- 26 ——— Adhesive and solder connection
- 27 ——— Bond wire
- 31 ——— Light distribution body
- 32 ——— Optical lens
- 41 ——— Hollow of (10)
- 42 ——— Reflecting layer
- 51 ——— Light guide
- 52 ——— Clip connection
- 110 ——— Lighting unit

- 120 — Printed circuit board
- 121 — Assembly side, upper side
- 122 — Underside of (120), other side, in given cases
- unassembled
- 123 — Through holes
- 124 — Frame
- 125 — Long hole
- 126 — Long hole
- 128 — Punched hole
- 129 — Punched hole
- 131 — Printed circuit board links
- 132 — Flanks of (131)
- 140 — Light emitting semiconductor chips
- 141 — Midpoint of (142)
- 142 — Surface of (140)
- 150 — Light distribution body
- 152 — Feedthrough link
- 153 — Cross-sectional surface
- 154 — Feedthrough link
- 155 — Cross-sectional surface
- 156 — Wraparound
- 161 — Light distribution section of (150)
- 163 — Fastening section
- 164 — Cylinder
- 165 — Light deflection body
- 166 — Optical lens
- 167 — Surface of (161)

168 ~~Surface of (152, 154)~~

169 ~~Surface of (156)~~

[0097] The invention has been described in an illustrative manner. It is to be understood that the terminology, which has been used, is intended to be in the nature of words of description rather than of limitation.

[0098] Many modifications and variations of the invention are possible in light of the above teachings. Therefore, within the scope of the appended claims, the invention may be practiced other than as specifically described.